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THE ANATOMICAL RECORD, VOL. 23, NO. 4
APRIL, 1922

Resumen por el autor, G. J. Noback.

Métodos simples para la correlacicn de las longitudes occipucio-rabadilla y occipucio-talón del feto humano.

El autor presenta una fórmula que hace posible la utilización de datos sobre el feto humano en términos de la longitud desde el occipucio a la rabadilla (altura del ejemplar sentado) la cual se desea comparar o combinar con datos semejantes expresados en la longitud desde el occipucio a los talones (altura total o altura del ejemplar en pié). La fórmula mencionada es la siguiente:

$$CH - \frac{3\,CR - 3}{2}$$

en la cual C corresponde a occipucio, H a talones y R a rabadilla.

Para determinar la longitud desde el occipucio a la rabadilla cuando se conoce la del occipucio a los talones se puede emplear una segunda fórmula:

$$CR = \frac{2\,CH + 3}{2}$$

Para determinar la exactitud de las fórmulas precedentes se han empleado las observaciones de varios investigadores que han publicado datos basados en ambas longitudes.

Translation by José F. Nonidez
Cornell Medical College, New York

AUTHOR'S ABSTRACT OF THIS PAPER ISSUED
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SIMPLE METHODS OF CORRELATING CROWN-RUMP AND CROWN-HEEL LENGTHS OF THE HUMAN FETUS[1]

G. J. NOBACK

University of Minnesota and the Medical College of Virginia

ONE FIGURE

Investigators in prenatal anatomy and development report their findings in one of three ways as regards length of the individuals studied. Some writers use both crown-rump and crown-heel length (Michaelis, '06; Mall, '10). Others use only the crown-rump (Streeter, '20), and some use the crown-heel alone (Meyer, '15; Scammon, '19; Noback, '21). Work based on one of these measurements alone is obviously difficult to compare with work based upon the other.

The relation between the crown-rump and the crown-heel lengths during fetal life is practically constant. The formulae here presented further demonstrate this fact.

The crown-heel length of the human fetus is equal to the crown-rump length (in millimeters) minus one, plus one-half of this amount. The following formula makes possible the utilization of data reported in crown-rump length which is to be compared or combined with data based upon the crown-heel length alone.

$$CH = \frac{3CR - 3}{2}$$

Illustration: The known crown-rump length is 95 mm. What is the corresponding crown-heel length?

$$CH = \frac{3 \times 95 - 3}{2}$$

i.e., the crown-heel length is 141 mm.

[1] The formulae in this report were demonstrated at the thirty-seventh session of the American Association of Anatomists, March, 1921.

The second formula may be used to determine the crown-rump length when the crown-heel length is known. It is expressed as follows:

$$CR = \frac{2CH + 3}{3}$$

Illustration: The known crown-heel length is 141 mm. What is the corresponding crown-rump length?

$$CR = \frac{2 \times 141 + 3}{3}$$

i.e., the crown-rump length is 95 mm.

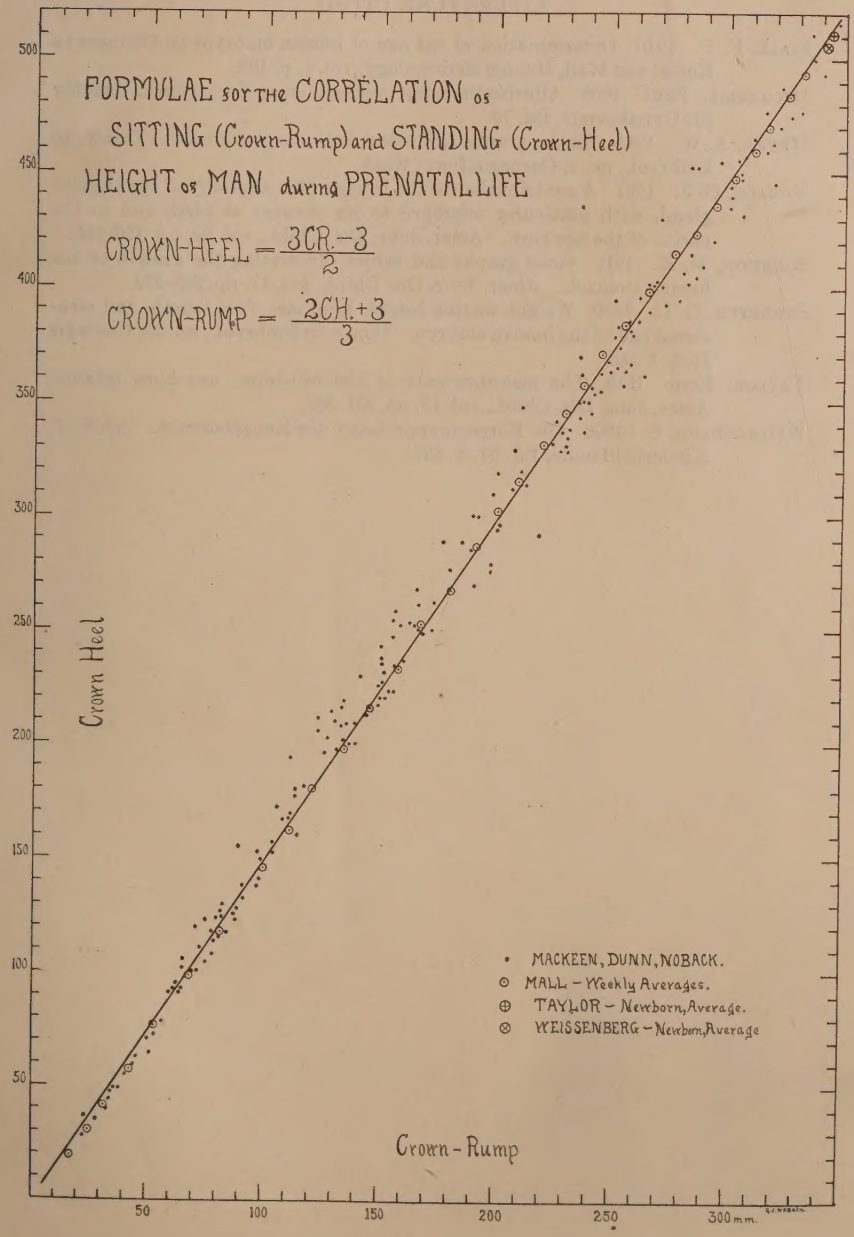
In order to determine to what extent measurements made by different observers would deviate from the formulae, I have plotted them on ordinate paper against the curve obtained by use of the formulae. The crown-rump lengths are represented by the abscissas and the crown-heel lengths by the ordinates. The accompanying plate shows the formulae curve as a straight line, and it is readily seen that the measurements made by the several observers are distributed quite evenly about it.[2]

The following table shows the extent of deviation from the lengths derived by formula in the data of Mall, MacKeen, and Michaelis.

	AVERAGE DEVIATION	PERCENTAGE DEVIATION
Mall (weekly averages of 1000 cases)	2.4	0.7
MacKeen (161 cases)	9.5	3.6
Michaelis (weekly averages from 14 weeks to birth)	11.5	3.3

Two sets of data on measurements of the newborn infant are also plotted against the curve. These observations were made by Taylor '19 and by Weissenberg '06. The averages of their measurements vary but a trifle from the curve derived by the formulae.

[2] Besides data of Mall and of Michaelis I have used measurements made in the Institute of Anatomy, University of Minnesota, by Helen Adams MacKeen and by Halbert Dunn. The work of the latter two investigators will appear in due course.


FORMULAE FOR THE CORRELATION OF
SITTING (Crown-Rump) and STANDING (Crown-Heel)
HEIGHT OF MAN during PRENATAL LIFE
CROWN-HEEL = 3CR.−3 / 2
CROWN-RUMP = 2CH.+3 / 3
Crown Heel
Crown-Rump
500
450
400
350
300
250
200
150
100
50
50
100
150
200
250
300 mm.
• MACKEEN, DUNN, NOBACK.
⊙ MALL – Weekly Averages.
⊕ TAYLOR – Newborn, Average.
⊗ WEISSENBERG – Newborn, Average

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Resumen por el autor, Leslie B. Arey.

Prueba directa del orígen monozigótico de los gemelos humanos idénticos.

Los gemelos humanos idénticos o mellizos homólogos se originan a expensas de un solo óvulo, conforme demuestra el autor por primera vez en el presente trabajo. El saco vitelino humano es un vestigio innecesario para el crecimiento o la diferenciación (incluso la vasculogénesis). La doctrina del orígen local de la vasculogénesis está soportada por los hechos, dentro de los límites de la posibilidad experimental, en los mamíferos.

Translation by José F. Nonidez
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AUTHOR'S ABSTRACT OF THIS PAPER ISSUED
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DIRECT PROOF OF THE MONOZYGOTIC ORIGIN OF HUMAN IDENTICAL TWINS[1]

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ONE PLATE (SIX FIGURES)

The commonest seat of ectopic pregnancy is the uterine tube. When such tubal gestations are plural, they may be either unilateral or bilateral in position. The former type, that is, the presence of more than one fetus in the same tube, is somewhat the rarer; a careful examination of the literature ('22 a) has yielded thirty-eight positive or authentic cases, eight probable or presumptive cases, and four possible but doubtful cases. To the positive list I have there added two new cases of monochorial twins, each unique of its kind. Detailed descriptions of these specimens, summaries of all the other cases, together with the general conclusions drawn from an analysis of the anatomical and clinical data afforded, may be found elsewhere ('22 a, '22 b, '22 c). This note is confined to the presentation of certain features of peculiar embryological interest and significance.

The first of the two new specimens,[2] consisted of a single chorionic sac which contained twin embryos, each 12.3 mm. long (fig. 1). There is a common yolk sac from which distinct yolk stalks arise near together and pass to their respective umbilical cords. The cut stumps of these yolk stalks and their separate origin from the sac are clearly shown in figures 2 and 3.

[1] Contribution no. 90.

[2] This twin specimen belongs in the collection of the Carnegie Institution, where it is listed as no. 1126. Acknowledgment is due the director, Dr. George L. Streeter, for permission to describe it. He has also furnished the accompanying photographs (figs. 1 to 3).

There has been no real doubt that human homologous or identical twins come from the division of a single egg. Many facts point incontestably to this conclusion; among such are their morphological duplicity, their occasional conjoining as 'double monsters,' and a common chorion.[3] Direct corroboration is furnished by the known manner of quadruplet development in the Texas armadillo, as well as by experiments and observations upon the lower vertebrates and invertebrates. Yet this specimen of human twins demonstrates for the first time their actual origin from a single yolk sac, and hence from a single ovum. Schwalbe's ('06) well-known reconstructions, based upon the Spee 1.54-mm. embryo, are purely hypothetical. Beside the present case, the only other illustrative specimens among mammals are the normal developmental stages of the Texas armadillo (Newman and Patterson, '10) and Assheton's ('98) single case of a sheep's blastodermic vesicle which bore twin germinal areas.

The second new twin specimen is in some respects even more interesting. Within the single chorion were twin embryos of 11.5 and 12 mm. (fig. 4). Each had its individual umbilical cord; these were attached to the chorionic wall, a quadrant's distance apart. Adherent to the amnion of one embryo (at the left in fig. 4) was a yolk sac of normal size; its cut stump may be seen in the photograph. The other embryo has no yolk sac. To make certain of this, both umbilical cords were sectioned throughout their lengths. That of the embryo at the left was typical for this age (fig. 5). The yolk stalk with its vitelline vessels lies in a coelomic extension; the level of the section here reproduced is too far distad to include the allantois. The cord of the embryo at the right is without microscopic trace of yolk sac or stalk, although the remaining structures are normal (fig. 6).

Certain deductions may also be made from this specimen. Mammalian monozygotic twins do not arise by the separation of early blastomeres, as too often has been assumed; on the

[3] In another publication ('22 c) it will be shown that a common chorion is not infallible proof of the monozygotic origin of human twins.

contrary, the common chorion which all twins of this sort possess proves at once that separation must be subsequent to the period when the cleavage group is differentiated into an inner cell mass and an outer shell of trophectoderm. That identical monochorionic twins arise by the fusion of separate ova need not seriously be considered, although it is apparent that some double ovum (fraternal) twins do become monochorial, in this way ('22 c). There is considerable evidence to support the belief that the twinning impulse occurs relatively late, at about the moment of gastrulation, which in mammals corresponds to the time of the formation of a primitive streak; the process, then, is simply one of double gastrulation. Studies on the development of the Texas armadillo (Newman and Patterson, '10) and Stockard's ('21) basic experiments and conclusions on the production of twins both substantiate this belief.

Exactly how determinate the mammalian ovum is in its development and how rigidly formative stuffs are localized are matters of speculation. The manner of fission into the two embryonic masses was presumably such that one received all, or essentially all, the cells destined to form a yolk sac; this again confirms the idea of a late moment for twinning when other cells had passed the stage of fundamental multiple potentialities.

The total absence of a yolk sac in one embryo which is otherwise normal in every way further demonstrates conclusively that this organ is not essential to the growth of an embryo or to the proper differentiation of its parts; indeed, the embryo in question is slightly larger than its twin, whereas both correspond closely in size to the norm for that menstrual age.

The embryo without a yolk sac is of further interest in relation to the ingrowth doctrine of vasculogenesis. In so far as such evidence is trustworthy, it supports rather the local-origin view, now generally acknowledged. That tiny vascular anlages of yolk-sac ancestry actually existed and at an earlier moment helped form primitive vessels by extension into the embryo is, of course, conceivable; also the theoretical possibility of vascular ingrowths from the early anlages in the body stalk are not excluded because of the characteristic and necessary nutri-

tive relations of the mammalian ovum. Fortunately, the fundamental truth of the local-origin doctrine rests on observations more rigorously controlled than this natural experiment which, however, was performed as perfectly as ever may be expected in a higher mammal.

In general, the yolk sac of man and the higher mammals appears to be an unnecessary vestige. In the earliest human embryos known, when it might be of real use, it is a simple entodermal sac containing masses of coagulum; growth to a conspicuous size is attained relatively late, long after adequate nutritional relations with the mother have been thoroughly established.

It is a great coincidence that both specimens of so rare a type should show features of such singular value and interest.

SUMMARY

Human identical or homologous twins for the first time are actually shown to originate from a single ovum.

The human yolk sac is a vestige unessential to growth or differentiation (including vasculogenesis).

The local-origin doctrine of vasculogenesis is supported within the limits of experimental possibility on mammals.

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PLATE

PLATE 1

EXPLANATION OF PLATE

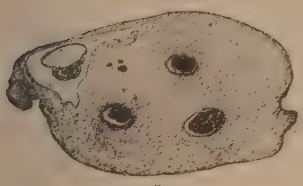
1 Photograph of 12.3-mm. human tubal twin embryos attached to a common yolk sac. × 2.2.

2 and 3 Additional photographs of the common yolk sac shown in figure 1. The origin of the separate yolk stalks is apparent. × 2.2.

4 Photograph of a pregnant human uterine tube. Part of the wall has been removed to show the twin embryos in place. The single yolk sac belongs to the 11.5-mm. embryo at the left. The 12-mm. embryo at the right lacks both yolk sac and stalk. × 1.7.

5 Photomicrograph of a section through the umbilical cord of the embryo at the left in figure 4. The yolk stalk lies in a coelomic extension. The level is too far distad to include the allantois. × 23.

6 Photomicrograph of a section through the umbilical cord of the embryo at the right in figure 4. There is no trace of a yolk stalk. The delicate tube below is the allantois. × 23.



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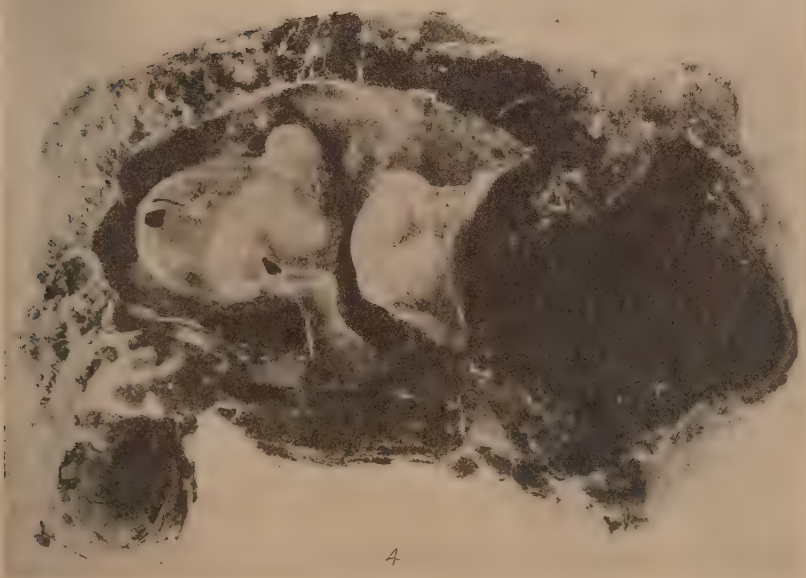

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Resumen por el autor, Leslie B. Arey.

Fusión coriónica y gemelización aumentada en el oviducto humano.

Los datos que poseemos hasta el presente indican que la relación de los gemelos monocoriónicos y la de los dicoriónicos es unas quince veces mayor en el oviducto que en el útero. Los estados ilustrativos indican que esta desproporción de los ejemplares monocoriónicos resulta en parte de la fusión secundaria de los sacos coriónicos de los individuos dizigóticos. Por esta causa, en el caso del hombre, el término monocoriónico no debe usarse siempre para expresar el orígen a expensas de un solo óvulo. Un factor todavía mas potente parece ser el aumento actual del impulso productor de gemelos. Su causa puede referirse más claramente a la inflamación tubal y sus resultados. Los mismos retardamientos y cesación del desarrollo que producen y siguen a la implantación tubal son responsables, respectivamente, de la gemelización excesiva y la malformación de los ejemplares obtenidos del oviducto.

Translation by José F. Nonidez
Cornell Medical College, New York

AUTHOR'S ABSTRACT OF THIS PAPER ISSUED
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CHORIONIC FUSION AND AUGMENTED TWINNING IN THE HUMAN TUBE[1]

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FOUR FIGURES

INTRODUCTION

Monozygotic twins of the higher mammals are necessarily monochorial. It is likewise customary to accept a common chorion as proof that mammalian twins are identical or homologous, that is, monozygotic in origin. This, however, need not be an infallible criterion. One of the armadillos, Dasypus villosus, has usually two monochorial young at birth; Fernandez ('15) has shown that these embryos at first occupy individual chorionic vesicles which then progressively fuse until they appear as one (3.5-cm. stage). Fusion of twin chorions among ungulates is apparently common; Lillie ('17) has proved beyond doubt that only rarely does such union fail in twin cattle and that it also occurs in the sheep and hog. There are no other data known to me. Lillie expresses the following opinion (p. 400): "A number of mammalian groups could be at once excluded from consideration because the conditions of placentation are such as to prohibit chorionic fusion; in mammalian groups such as primates and many rodents in which the ovum becomes embedded in the uterine mucosa, there is, of course, an insuperable bar to early chorionic fusion." Nevertheless, in the human tube at least—and here, except spatially, the conditions of implantation are essentially identical with those in the uterus (Mall, '15)—indications of chorionic fusion occur. This truth became apparent during an analysis of the data accompanying the recorded cases of tubal twin pregnancy ('22 a). The supporting evidence will now be presented.

[1] Contribution no. 92.

STATISTICAL EVIDENCE OF CHORIONIC FUSION

First, the subject is best approached statistically. A rigid examination of the literature has revealed forty cases of tubal twins that appear authentic ('22 a); in addition there are eight cases which may be termed probable or presumptive. Among the positive list thirty-one specimens are recorded as having a common chorion, although apparently four more should be included, whereas in three only was it double.[2] In the probable group there are six definite statements; four of the six cases have double chorions.[3] Combining both sets, the ratio becomes 33 (or possibly 37) : 7. To the list of double-ovum twins must be added those that develop bilaterally, one in each tube. There appear to be less than a dozen proved cases.[4] Hence the total records show that monochorial specimens occur twice as frequently as the dichorial cases.[5] Since, however, viable (uterine) identical twins are but one-seventh as frequent as the ordinary fraternal type, it follows that tubal monochorial twins are some fifteen times more common than might be expected if the tube were no more favorable than the uterus as a seat for twin production.

[2] In one of the three the evidence is not unequivocal for doubleness.

[3] This relatively high ratio of doubleness is explained largely by the fact that duplicity itself was one of the determining factors utilized in rejecting several inadequately established cases from the positive group.

[4] McDonald and Krieger ('13) collected the recorded cases of bilateral tubal pregnancy. They listed twenty-five proved cases, including both twin and successive specimens. Only in nine instances were both fetuses present and of the same age; in eight cases they were of different ages (including two with one member a mummy and one a lithopedion); two specimens had a fetus in one tube paired with a clot and villi in the other; in two cases there were clots with villi in both tubes. Twenty-seven additional cases were listed as 'probable but not proved'; as a matter of fact, in none of these instances was there positive anatomical evidence of bilateral gestation, either twin or successive; sixteen combined a fetus in one tube with a hematoma without villi in the other, while eleven were represented by hematomata in both tubes.

[5] In this computation that group of dichorial cases which combine a simultaneous tubal and uterine pregnancy was, of course, ignored, for it belongs properly to neither category. Furthermore, comparable tubal conditions which allow one member of such pairs to descend uninterruptedly doubtless subtract a proportionate number from the monozygotic tubal specimens.

In view of these numerical relations, the preponderance of monochorial tubal twins seems to offer prima facie evidence of some modifying factor or factors. What these are will next demand consideration.

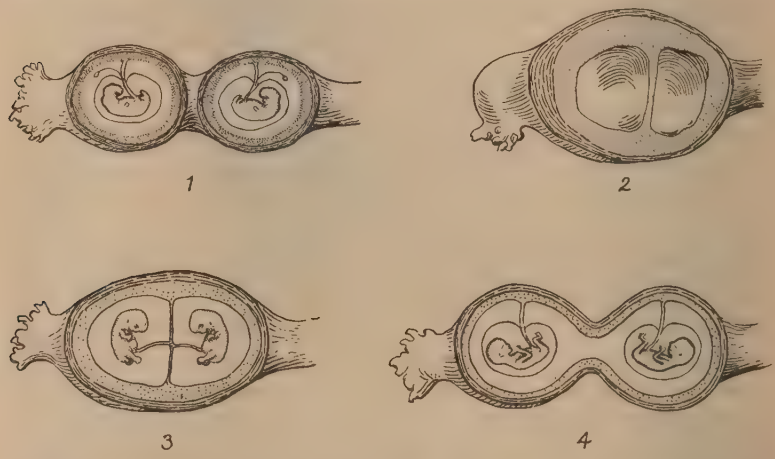
ANATOMICAL EVIDENCE OF CHORIONIC FUSION

The readiest explanation of the foregoing numerical disproportion is that separate ova have fused to produce pseudomonochorial twins. With this hypothesis in mind, the descriptions of all recorded cases of unilateral tubal twins were examined to ascertain if there is evidence of chorionic fusion in man. Briefly, such evidence does exist, as the following selected cases exemplify.

First in the series is Young's ('11) specimen, which comprises a tube with two dilatations; one represents a ruptured chorionic sac with its embryo still inside; the other sac was unruptured, entirely distinct from the first, and contained a twin embryo. Amann's ('08) case is apparently in the same category, and the clinical histories and anatomical descriptions recorded by Ferroni ('03), Saniter ('05), and Shauta ('05) make it probable that these also should be included. There is more doubt in the cases of Fenger ('91) and Salin ('95); they may be successive pregnancies. Figure 1 is a diagram of this preliminary condition based upon Young's specimen. Whether these particular ova ever would have fused had development continued or whether they were too far separated is unimportant; they typify the primary relation.

The next stage in fusion is illustrated by a tubal pregnancy described by Mall ('15) and Meyer ('20), listed in the Carnegie collection as no. 825 (fig. 2). Externally the tube bore a single swelling the size of a walnut, but section revealed two well-preserved chorionic vesicles, lying at about the same transverse level in the tube and flattened on the surfaces of mutual contact. The opposed chorionic faces had the appearance of a thin septum (Mall, pl. 9, figs. 4 and 5; Meyer, fig. 1), which proved to be double, partially separated by villi. Actual embryos and amnia had disappeared.

Pulcher ('05) has described a fusion still more advanced; it is a stage just prior to complete union (fig. 3). At the middle of the tube was a tumor the size of a fist. Its interior was divided by a thin translucent septum into two chambers, each of which contained a well-preserved 2-cm. embryo. Both umbilical cords were inserted near the center of the common septum. This partition was studied microscopically by sections; it is said to consist of a double layer of amnion. Nevertheless, since the umbilical cords pass to the septum, it must funda-



Figs. 1 to 4 Stages illustrating secondary chorionic fusion between dizygotic tubal embryos. Fig. 1, Young's specimen; fig. 2, Mall's specimen; fig. 3, Pulcher's specimen; fig. 4, Costa's specimen.

mentally represent a former double chorionic wall which had thinned and degenerated until it was no longer recognizable as such to the investigator.[6] During the growth of these ova, the nutritional mechanism necessarily became progressively incompetent. Under these conditions, the embryos should be underdeveloped; in accordance with this expectation, we find the

[6] Possibly the amnion was a constituent as well; each chamber is said to be lined with a 'smooth glistening membrane.' As this was the author's inaugural thesis, he presumably studied the specimen with care, although he failed properly to interpret the septum or the significance of the insertion of both umbilical cords in it.

menstrual histories indicating fetuses of twelve to fourteen weeks, when in reality they measure but 2 cm., which corresponds to seven weeks' normal development. It was a fortunate chance that the umbilical cords were inserted in the abutting chorionic walls; otherwise the specimen would have passed (as Pulcher believed) for twins with a common chorion and double amnion.

The final step in fusion is furnished by Costa ('07). Externally, the tube exhibited two dilatations, well separated and apparently distinct; internally, a neck-like constriction partially divided two communicating compartments, each of which contained a fetus, 5 and 5.3 cm., respectively (fig. 4). It is, of course, possible to interpret this as a single gestation sac secondarily constricted, but as it is a normal specimen, preceded by graded stages, fusion is more logical. The chances are greatly against the coincidence of single-ovum twins being so significantly spaced within a doubly dilated tube and chorion.[7]

Absolute proof of chorionic fusion waits upon the finding of male and female fetuses inside a common sac. Eventually such specimens may be confidently expected, especially since it is now possible to recognize sex in embryos as small as 15 mm. (Spaulding, '20).

In supplemental support of the principle of chorionic fusion, it is significant that two fetuses may occupy one gestation sac even when the history and anatomical relations point clearly to successive, rather than simultaneous pregnancies. Hence fusion, or inclusion, is certain. An illustrative case is that of Henricius and Kolster ('99), who attended a woman during two successive pregnancies without delivery on either occasion; at autopsy the left tube proved to be a single sac which contained a recent full-term fetus and a mass of fetal bones. A similar case is recorded by Racoviceanu and Bogdanovici ('04); the patient twice went to term without delivery; the right tube was a sac which contained a small, shrunken, but well-preserved fetus and an old lithopedion.

[7] Mall ('15) has described rare cases of degenerating ova without embryos which assume an hour-glass shape during dissolution. This process has no relation to Costa's specimen.

In passing, it should be mentioned that the amnia of twins also join readily. Twelve cases in the twin series specifically mention this point; in eight specimens the amnion was single.

AUGMENTED TWINNING IN THE TUBE

Although chorionic fusion may be invoked satisfactorily to reduce in part the preponderance of monochorial tubal twins, it is pertinent to inquire if the relative frequency of monochorial tubal twins may not be largely explained by an excessive production of monozygotic twins rather than by the fusion of the chorionic sacs of dizygotic individuals. In order to return an answer, it is necessary to consider both the cause of twinning and of tubal implantation.

Stockard ('21) has been able convincingly to reduce the primary cause of all non-hereditary abnormal development, including true (monozygotic) twinning, to a single factor—developmental inhibition or arrest; the exact type of deformity that results depends solely on the precise moment when the interruption occurs. Thus, twin formation results from a slowing of the developmental rate at the time of gastrulation, which in mammals corresponds to the period of the primitive streak. Such an arrest allows other potential embryonic axes on the blastoderm to assert themselves, whereas in normal development they are dominated and suppressed by the chief axis. Direct experimentation on fishes refers the cause of arrest to retarded oxidations. Occasional twinning in the chick and the customary quadruplet formation in the Texas armadillo lend strong support to this view. Both are subject to arrest and reduced oxygen supply—the chick by a lowering of the temperature when laid, the armadillo blastocyst by a quiescent period of several weeks in the uterus before it becomes implanted.

The direct application of this fundamental concept to abnormalities and twinning in the human tube follows logically when once the conditions attending tubal implantation are known. Mall ('15) studied the extensive Carnegie collection of embryos, in which many clinical histories accompany the specimens. He concluded that tubal pregnancy is associated with

preceding inflammatory changes, usually of long standing. It appears that such inflammatory disturbances may continue over long periods during which the inflammation is constantly too severe to permit the germinal products to unite or maintain development; later, however, the condition may abate sufficiently so that the ovum can develop, at least for a time, although it is still incapable of reaching the uterus.[8] Incidentally, it seems probable that if tubal pregnancy had not occurred in these cases when it did, the tube might soon have healed sufficiently to allow ordinary uterine gestation to proceed. The ovum fails to gain its normal destination in the uterus because of the impairment of the ciliated cells, as well as by kinkings of the tube through adhesions, by becoming trapped in epithelial diverticula of inflammatory origin or through adherent mucosal folds. "In short any change which delays the ovum in its progress will favor tubal pregnancy." An ovum taken up by the mucous membrane at the outer end of the tube may be delayed by the impaired ciliated cells until it is too large to pass the narrow end of the tube; it may wander into blind pockets or diverticula; more commonly still it is transported to the middle of the tube, where inflammation and follicular salpingitis are most common, and there become stranded because the ciliated cells can carry it no farther. Any of these delays, therefore, to which may be added the rarer hazards afforded by blind tubes, pocketed and double tubes, or delays due to migration from the opposite ovary, are the effective primary factors conditioning tubal implantation.

When the normal progress of the ovum is blocked in one of the ways designated it may then attack the tubal wall; in the meantime, however, it has attained a later stage of development than is customary at implantation. If, therefore, such delayed implantation and the establishment of tardy or inadequate oxygen relations (see below) should cause a developmental slowing at the critical moment for twinning, two embryonic axes would assert themselves as in the fish, chick, and armadillo, and monochorial twins result. This outline of events becomes a natural

[8] In another publication ('22 b) I have shown that this sterile period averages nearly six years.

inference when Stockard's discovery is applied to the known condition of the tube and ovum in tubal pregnancy. It helps account rationally for the preponderance of single-ovum twin pregnancies in the tube, which, by its greater susceptibility to prolonged and slowly clearing chronic inflammation, further explains why the uterus bears relatively fewer monozygotic twins.

The theory of Stockard is further supported in its human application by the demonstrable frequency of faulty implantation in tubal cases and its relation to malformation of the parts. Mall failed to find a typical decidua here, and hence its function in checking hemorrhage by forming a dam between the tips of the villi and the eroded mucosa is foregone. There result numerous hemorrhages which form old clots between the villi. "Even the best of specimens frequently show such extensive hemorrhages around the chorion and such marked degeneration of the villi that it is a wonder that the ovum continues to grow normally." Checks, permanent or temporary, while the chorion is struggling to overcome natural deficiencies in its nidus are sufficient to account both for excessive twinning, if the delay prior to implantation be not sufficient, and for the observed double frequency of anomalies in these specimens over the uterine group.[9]

Mall held that the primary causative factor of these pathological embryos is faulty implantation which prevents an adequate transfer of nutriment. Stockard agrees with the primary factor, but from his experimentation is forced to attribute the proximal cause to inadequate oxygenation.

SUMMARY

The available data indicate that the ratio of monochorial to dichorial tubal twins is about fifteen times greater in the tube than in the uterus.

Illustrative stages indicate that this disproportion of monochorial specimens results in part from the secondary fusion of

[9] Mall ('17) studied the anomalies of 1000 embryos and records that tubal monsters are twice as common as those in the uterine group.

the chorionic sacs of dizygotic individuals. Hence for man the term 'monochorial' need not always connote a single-ovum origin.

A still more potent factor appears to be an actual augmentation of the twinning impulse. Its cause is most clearly referable to tubal inflammation and its sequelae. The same delays and arrests which cause and follow tubal implantation are respectively responsible for the excessive twinning and malformation of tubal specimens.

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Resumen por el autor, C. E. Tharaldsen.

Una estufa de inclusiones en parafina para uso individual.

El presente trabajo es una descripción de la construción y modo de funcionar de una estufa para inclusiones en parafina, adaptada para colocarla en una mesa de uso individual, la cual incluye facilidades para infiltración, inclusión, extensión de los cortes sobre porta-objetos, para secar, matar bajo la acción del calor, fijar y teñir en caliente, combinadas todas ellas en un aparato compacto dispuesto de tal modo que los objetos reciben el calor desde la parte superior del aparato y están situados convenientemente para el técnico. Las unidades que susministran calor consisten en dos bombillas eléctricas de 16 bujías, que pueden operarse por separado mediante una resistencia de cinco unidades, por medio del cual puede regularse la temperatura con rapidez y exactitud.

Translation by José F. Nonidez
Cornell Medical College, New York

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A PARAFFIN OVEN FOR INDIVIDUAL USE

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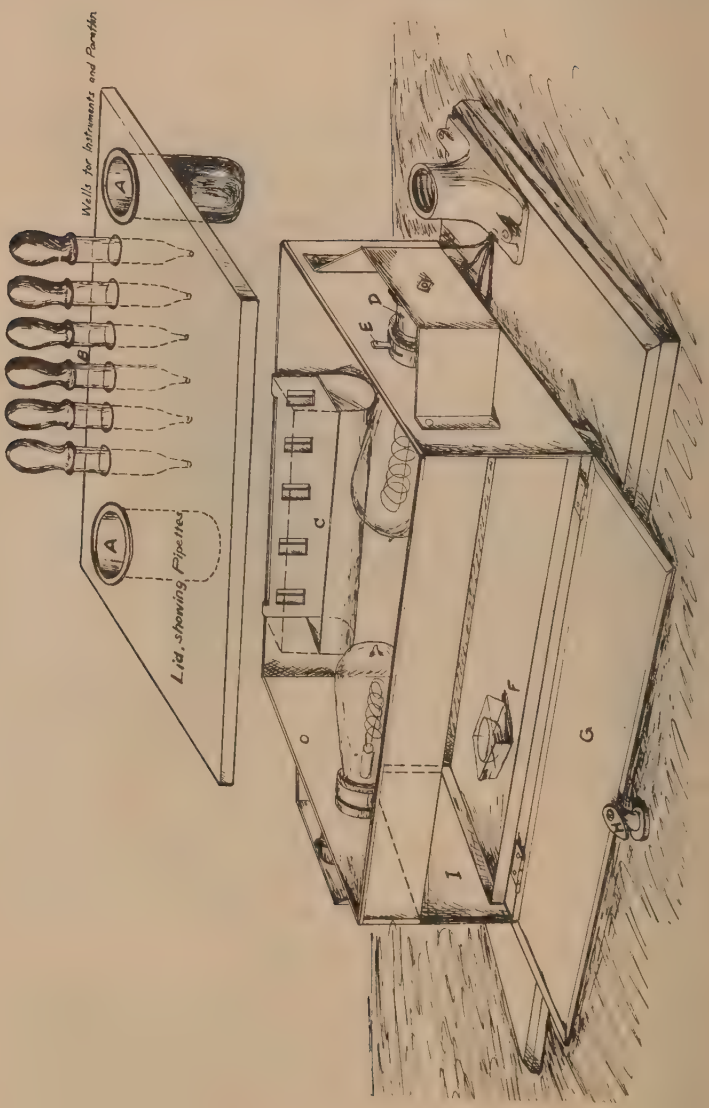
ONE FIGURE

That the inefficiency of our common types of paraffin ovens has been long felt is evidenced by the many home-made contrivances which have been devised to overcome this or that difficulty. Necessity, that prolific mother of invention, has indeed been bountiful, for what microtomist does not have his own contrivance for the paraffin process! A survey of such of these as have been described shows that the trend has been away from the large and elaborate ovens, towards the small, compact device that can be placed on the individual desk, where it is instantly available for use. The danger of fire from rheostats, gas and oil burners has long since led to the common usage of electricity as a safer source of heat, at the same time making possible the additional advantage of illumination. The time-consuming process of regulating water-baths has caused many to discard these in favor of a direct heat source from above the objects, thus securing a more rapid and uniform distribution of heat by radiation. The inconvenience and expense of several pieces of apparatus adapted to some particular phase of the paraffin process, i.e., infiltration, imbedding, spreading sections, drying slides, hot fixation, and staining, has led to repeated attempts to incorporate all these features in one machine.

It is one of these home-made contrivances which I have been requested to describe. This paraffin oven is one which for several years has been slowly evolutionizing in the Zoological Laboratory of Columbia University. The last model, which was designed by Young, formed the nucleus about which the present oven was constructed. This model, constructed in the Zoological Laboratory of Northwestern University, has now been installed


Wells for instruments and Pencils
A
A
B
Lid, showing Pipettes
C
D
E
F
G
H
I
K

in both of the above-named institutions as well as several others, as an oven for individual use. In its construction it embraces all of the above-mentioned principles in one compact apparatus, and in these institutions its efficiency has been demonstrated by thorough trial. Steps are being taken to have it patented, not for the purpose of exploitation, but rather to protect it from such, that it may be available at a minimum cost.

The oven consists of a rectangular metal box of firm construction, measuring 10″ × 5″ × 6″, mounted on a wooden base. The heating unit consists of two carbon filament 16-c.p. electric lights, each mounted in a five-unit reductor control (*D*) which is regulated by means of a lever (*E*). These reductor units and levers for their control are located at the upper part of either end of the oven so that they are conveniently placed for regulation, and the whole is firmly supported and protected by guard plates. On the floor of the oven a movable tray (*F*) is fitted for containers of paraffin, etc. In this way an even distribution of heat is secured on the objects by radiation from above, and at the same time they are illuminated conveniently for manipulation. By means of levers the temperature can be regulated to suit the conditions demanded by the nature of the work, from that of slight warmth for drying purposes to beyond the melting-point of the hardest paraffin. Expensive and inconvenient thermostats, rheostats, and thermometers have been eliminated from the equipment as unnecessary.

The front of the oven consists of a door (*G*) which opens downward, the knob (*H*) of which is of such a length that the door when open lies on a level with the floor of the oven. This surface thus serves the purpose of a shelf on which the tray for paraffin containers can be moved out or in for greater convenience in transferring tissues, orienting objects, or for imbedding. It also serves as a secondary temperature control in short time infiltration for finer cytological work. On either end wall of the oven is located a metallic wing (*I*), which can be pulled out even with the tray on the surface of the door. This is for the purpose of protecting the paraffin from side drafts, should this be found necessary. For longer infiltration methods, such as

are required by some plant and larger pieces of animal tissues, the tray is left in place and the door closed, after which the temperature is regulated.

The top of the oven consists of a removable lid, in the rear corners of which are suspended two wells (*A A*), one for containing the stock paraffin and the other for holding needles and such other instruments as are used in work with paraffin. Thus the paraffin and instruments are conveniently accessible, and both, because of their location to the rear of the heating units, are kept at a temperature most favorable for such work.

Between these two wells are six holes (*B*) in which are suspended paraffin pipettes. These pipettes hang down into a trough (*C*) which serves the dual purpose of collecting paraffin drippings and of regulating the temperature of the pipettes for the paraffin work. For the latter purpose a series of vents are arranged on the rear wall of the trough which correspond to a similar set on the rear wall of the oven. The temperature of the interior of the trough is controlled by sliding the one series of vents over the other, thus regulating the size of the aperture.

The front two-thirds of the lid is flat and without obstructions. Its temperature can be regulated from high to low uniformly, or one side can be maintained at a higher temperature than the other by means of the levers at either end. This surface thus serves as a very efficient warm plate for the spreading of sections on slides without danger of melting the paraffin. It may also be used for hot staining on the slide without danger of boiling or burning, such conditions as are required by the carbol-fuchsin smear preparations of sputum or the Benda and Bensley methods.

For the rapid drying of sections on slides after spreading, the process is conveniently accomplished by placing the slides on cardboard, which is then placed on the tray, after which the door is closed to protect from dust, and the temperature is then regulated to a gentle warmth. The slides may be thus exposed indefinitely without danger.

Hot fixation and killing are accomplished by regulating the oven to the proper temperature and then placing the objects in a container of the desired fluid on the tray where it may be exposed for the proper length of time without danger of overheating.

For finer cytological work the oven has proved very efficient as a safe and convenient method for infiltration and imbedding. When exposure to xylol-paraffin mixtures is used, this may be accomplished on the tray as described above for hot fixation. The practice of passing the objects through several changes of paraffin may here be accomplished with all facilities conveniently placed and illuminated before the operator so that even a binocular microscope can be used when necessary, with the objects still under the proper temperature conditions. Square flat glass salt cellars are usually used as containers in this process. The button method of imbedding is facilitated if carried out on the tray where the temperature can be regulated so as to give sufficient time for the proper transfer and orientation of the objects before the paraffin is allowed to cool.

The parts of the oven are all demountable so that they may be readily removed for cleaning. Oil or gas burners or electric rheostats not entering into its construction has practically eliminated the danger of fire, and the oven may therefore be left in operation indefinitely with perfect confidence. Its light weight, compact and firm construction make it possible to transfer it with ease, and it can be kept on the individual research desk convenient for use without monopolizing this sometimes precious space.

Resumen por el autor, Bruno Oetteking.

Patelas anómalas.

Una indicación de la inserción del músculo vasto lateral en el lado supero-lateral falta raras veces en la patela o rótula. Las inserciones en este punto producen a veces profundas escotaduras o emarginaciones como resultado de la función muscular en conexión con procesos selectivos, tales como la economía en el material formativo y las influencias del medio ambiente que ejercen su acciòn sobre la textura del hueso. La emarginación está a veces ocupada par patelas accesorias ("patélulas"). Las condiciones patológicas y los huesos accesorios no son los agentes causantes de la formación descrita.

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ANOMALOUS PATELLAE

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FOUR TEXT FIGURES AND ONE PLATE (TWO FIGURES)

Of the few anomalies met with in the human patella, that of emargination is not at all scarce. It occurs invariably on the upper outer margin of the bone, taking on a great variety of form, particularly with regard to the extent and depth of the incisure produced by the emargination. While only the extreme cases of emargination are of interest to the anthropologist, it may be well to reflect first upon the anatomical significance of the anomaly. The latter is preëminently to be understood from the mechanical or functional angle, and as such is closely involved in the articulation of the knee-joint. It has been shown that during the act of flexion the patella moves laterally under duress of the trochoginglymus character of the knee-joint, to assume an external position in complete flexion, i.e., a position in front of the lateral condyle of the femur. In this position only a narrow marginal area on the medial side of the articular surface of the patella is in touch with a similar marginal area on the lateral tibial surface of the medial condyle of the femur, forming here a distinct facet of semilunar or crescentic shape. The strain of flexion is withstood by the patellar ligament, the prolongation of, and continuous with the common tendon of m. quadriceps femoris and inserted in the tuberositas tibiae. It is this direct strain that in flexion somewhat sidetracks the patella laterally. The main agent here, as Kempson ('02, p. 420) has shown, is the tendon of m. vastus lateralis inserted into the upper portion of the lateral margin of the patella, in coöperation with the tractus iliotibialis and the retinaculum patellae laterale (fig. 1).

As to the variableness of insertion, there is hardly a patella found without showing at least an indication of it, quite frequently in such a case in the shape of a smooth and slightly depressed or semilunar edge of about 1 cm. or more in extension. Todd and McCally ('21), who have examined 682 skeletons, state that there

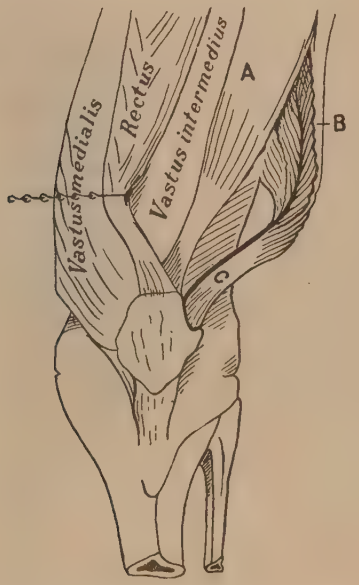

Fig. 1 The insertion of m. vastus lateralis. The upper part, *A*, of the muscle is divided from the lower part, *B*, by a longitudinal incision. The muscular fibers are seen inserting into the two surfaces of the tendon, *C*, which is inserted in the superolateral margin of the patella (modified after Kempson).

are "about three per cent of human beings characterized by more or less marked defect of the upper and outer part of the bone." This is a rather low occurrence, but of significance in view of the large material investigated. Pronounced cases of emargination with hook or spine-like projections are sometimes the result of multiple patellar formation, as pointed out by Wright ('04), who says on page 66:

The explanation which I have to offer for the emargination to the patella . . . . is that in addition to the central deposit of cartilage cells in the quadriceps extensor tendon which forms the patella, we not infrequently get an outlying deposit in the anterior fibers of the iliotibial hand of fascia lata; that this deposit when it occurs is usually small; that it joins the central deposit, its presence being indicated by the process which gives to the patella its occasional emarginated appearance.[1]

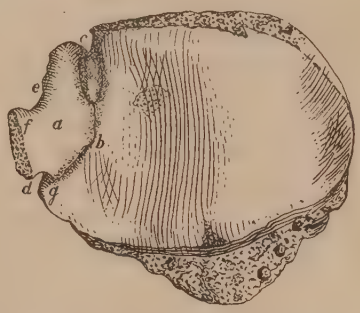

Fig. 2 Articular surface of a patella from Santa Catalina Island, California (no. 609). *a*, accessory patella ('patellula'); *b*, furrow caused by the coalescence of the patella and 'patellula'; *c* and *d*, upper and lower clefts of incomplete coalescence; *e*, insertion line of m. vastus lateralis, continuous with *c*; *f* and *g*, spine-like projections at lower ends of patellular and patellar notches.

That this assertion is exactly to the point in certain cases is demonstrated by a left patella in our collections from Santa Catalina Island, California (no. 609), which may be seen illustrated in figure 2. The bone shows on its upper lateral side an unevenly lozenge-shaped accessory 'patellula' (*a*), whose articular surface is set off against the articular surface of the patella proper by a distinct, but otherwise smooth and fairly deep furrow (*b*). The two elements are incompletely coalesced above and below, leaving in these two places distinct and relatively deep clefts (*c* and *d*). The anterior patellular surface, somewhat circular, is slightly bulged and rugged in continuation with the patellar sur-

[1] Pearson and Davis, in a comprehensive comparative study on the sesamoids of the knee-joint, assert that "in the knee-joint itself we have come across no less that ten sesamoids . . . ." ('21, p. 134), which are fittingly named by them in accord with the older nomenclature.

face, against which it is set off only by a somewhat broad and shallow depression. The anterior surface of the accessory bone is at 23 mm. almost doubly as wide as the posterior or articular one at 13 mm., while its height measures 22 mm. But the more important point here is that the 'patellula' is deeply set into a notch of the patella proportionate to the former's size. Although the theory of accessory patellae as advanced by Wright is plainly demonstrated by the case just described, it seems to be doubtful to the present writer whether the more or less spine-like projections at the lower end of the emargination unimpaired by the accessory element is due to the same origin. In none of the cases that came to his attention has he seen a demarking furrow or an indication of it between the spine and the bone proper comparable to the condition mentioned in connection with the area of coalescence between the patella and 'patellula' just described (no. 609). And again is the patellar notch, for instance, in the case to be described below, considerably deeper than simply to be caused by the spine-like projection in justification of Wright's assertion that, "the process gives to the patella its occasional emarginated appearance," which at best might only serve to emphasize the emargination. This is furthermore proved in figure 2, *c-e*, where the insertional line of the vastus lateralis muscle continues from the patella proper upon the 'patellula,' thereby transgressing the upper cleft of incomplete coalescence (*c*), and forming a spine-like projection of its own at the lower end of the patellular insertion (*f*). But the lower termination of the patellar notch that lodges the 'patellula,' also projects spine-like (*g*), and although not coalesced with the 'patellula,' the outlines of the latter and the patellar projection are continuous over the lower cleft of incomplete coalescence (*d*) to form the lateral boundary of the common articular surface. A coincidence like this in the formation of similar projections in analogous and near-by places is hardly conducive to assuming their origin from specific accessory elements. There is, however, a patella figured by Todd and McCally ('21, pl. II, no. 10), in which the spinous process at the lower end of the emargination seems to be of an accessory nature, since a distinct furrow divides the two elements, the process and the bone.

The patella in our collections (no. 697, from Chihuahua, Mexico) that called for a special investigation on account of its deep superolateral notch is rather delicate, medium sized, and of somewhat rounded or, still better, broad oval-shaped appearance. It may be seen in plate 1, as figure 5, *a* and *b*, sided with the patella just described and enumerated as figure 6, *a* and *b*. It is a left patella. Its anterior surface shows the longitudinal ridgings peculiar to this bone, and as many as twelve more or less distinct nutrient foramina. On the basis is seen the typically smooth and fairly deep horizontal groove of insertion, while the

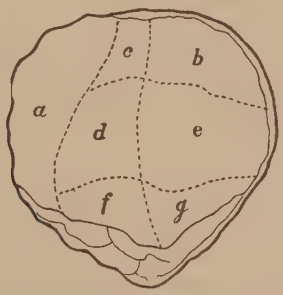

Fig. 3 Articular surface of a right patella (after Luther Holden). *a*, *b*, in contact with femur in complete flexion; *b*, *c*, in contact with femur in rectangular flexion; *d*, *e*, in contact with femur in semi-extension; *f*, *g*, in contact with femur in complete extension.

apex, bluntly pointed, appears to be smoothed down in front. On the articular side the basal margin is slightly turned inward toward the articular surface, while the rugged apex recedes from the articular surface medially to the amount of 5 mm., its lateral region being almost on a level with the articular surface. The facies articularis itself shows the typical slopings from a vertical ridge, the crista faciei articularis, toward the medial and lateral borders, to form its larger lateral and smaller medial portion. The facetation of the articular surface is also in evidence, particularly the medial vertical facet, which is markedly concave from side to side at a width of about 9 mm. and an approximate depth

of 2 mm.[2] The outstanding feature of this patella is the deep notch which at its lower end is pyramidally pointed, to form a spine-like projection. At its bottom the notch is considerably roughened, baring here the two compactae and the intermediate spongiosa. The deepest place is situated at about the level of the horizontal halving line of the entire bone, or, counted from below, between the first and second thirds of the articular surface. The anteroposterior diameter between the margins of the notch amounts here to 9 mm. The distance between the two footpoints of the curve demarking the outline of the emargination measures 21 mm., while its depth comes to 5 mm. This is quite

[2] Besides H. Meyer ('53) it was John Goodsir who really seems to have been the first to bring conclusive evidence regarding the principal stations in the articulation of the knee-joint as expressed by certain definite marks on the cartilage of the articular surfaces, particularly of the patella. As his elaborations on the subject are of fundamental importance, but on the other hand rather difficult of access, the reprinting of part of his article may be welcome here. The present writer has supplemented it for visual information by a diagram (fig. 3) after Luther Holden (Human Osteology, London, 1899, 8th edition, fig. 13, p. 215).

John Goodsir ('68, pp. 224–226) writes: "The patella exhibits various interesting relations during the movements of the joint; and in addition to those observed by Meyer, others hitherto unrecorded may be pointed out. Meyer states that the under half of the patella is in contact with the femoral trochlea in extension, and the upper half in flexion; but if the bones are carefully examined, the following configuration and relation of its articular surface will be detected. Instead of two faces, a greater external, and a lesser internal, separated by a perpendicular ridge, as usually described, the surface presents, in every instance, six, frequently seven, facets, separated from one another by two perpendicular and two transverse ridges. The external perpendicular ridge is the one commonly described. The internal cuts off a small elongated perpendicular facet at the inner edge of the surface. The two transverse ridges only extend inwards to the inner perpendicular ridge, so as to separate from above, downwards, two superior, two middle, and one or two inferior facets, the external of the two latter being constant. The relations of the articular surface of the patella present four groups. In complete flexion, the internal or perpendicular facet is in contact with a remarkable crescentic facet, which bounds the oblique curvature of the inner condyle of the femur. In none of the other positions of the joint is this internal patellar facet in contact with an opposite cartilaginous surface, but is covered or sheathed by what may be denominated the internal patellar pad. At the same time, the external superior facet lies upon the fore part of the external condyle of the femur below and behind its bounding groove. These two facets are the only parts of the patella which come in contact with the proper femoral condyles. They do so only in complete flexion: and in this state all the remaining facets are in contact with the great infrapatellar pad, and the so-called mucous ligament.

considerable and becomes still more evident in comparison with the Krapina patella (Gorjanović-Kramberger, 1906, 239) whose outlines are seen sided with the Mexican one under discussion in figure 4, *a* and *b*. The absolute diameters of the two bones differ mostly in the height and thickness and may be studied from the adjoined comparative table, wherein the Spy measurements from the same publication by Gorjanović-Kramberger (p. 239) are also listed. The upper external portions of the margins of the Mexican and Krapina bones, as seen from their posterior or articular surfaces, are drawn in figure 4, *a-c*, first singly and then in superimposition, coinciding on their lines of deepest emargina-

"In the second stage of extension, the superior internal and external facets are in contact with the inferior portions, respectively, of the inner and outer halves of the femoral trochlea; the internal perpendicular facet being sheathed as before stated, and the remaining facets being in contact with the great infra-patellar pad.

"In the third stage of extension, the superior internal and external facets leave the femoral trochlea and become sheathed, and the space occupied partly by the supra-patellar, but principally by the supra-trochlear pads. The middle internal and external patellar facets now come in contact with the middle portions respectively of the inner and outer halves of the femoral trochlea; while the internal perpendicular and the two inferior facets are sheathed and padded as before.

"In the fourth or last stage of extension, the middle internal and external facets also recede from the surface of the trochlea, and along with the internal longitudinal already sheathed become applied against the fore part of the femur above its articular surface, the intervening space being stuffed by the supra-patellar, supra-trochlear, and upper pads, in the ascending cul-de-sac of the synovial membrane. In this last stage, the only portions of the patella in contact with the cartilaginous surfaces of the femur, are the inferior internal and external facets, or the latter, if one only exists. These slip somewhat abruptly upwards and inwards upon a narrow ledge or furrow, which terminates the femoral trochlea above, and forms a resting-place for the inferior facets of the patella in the complete extension of the joint."

The six or seven articular facets which Goodsir points out as typical in the European patella are naturally somewhat blurred in the dry bone. In the recent state, however, they are quite marked in the thick layer of cartilage that covers the posterior surface of the patella, the thickest in fact, in the entire skeleton, attaining a thickness of from 5 to 6 mm. over the crista verticalis. The number of articular facets does not seem to be constant, however, and their shaping is subject to the influences of function. In this respect, Lamont ('09/'10) found the medial perpendicular and particularly the lateral superior facets enlarged in the Punjabi as a result of squatting. The author appends that the same condition has been stated by Macalister as "very common in ancient Egyptian patellae."

tion. These latter measure 2 mm. and 5 mm., differing by 3 mm. in favor of the Mexican patella. It will be readily seen that the extent of the curve describing the emarginations is also greater in the latter bone where it amounts to 21 mm. against 11 mm. in the Krapina bone.

	PATELLAR MEASUREMENTS		
	Mexico	Krapina	Spy
	mm.	*mm.*	*mm.*
Width	44	49 46.6	51.4
Height	42	42.3–44.4	46.3
Thickness[1]	19	23.2–42.0	22.2–24.0
Dimensions of articular surface:			
Height	25		
Width	44		
Dimensions of emarginations:			
Length	21	11[2]	
Width	9		
Depth	5		
Angle of articular surfaces	124(129°)[3]	109–110°	119°

[1] Gorjanović-Kramberger ('06, 239) lists: 'Dicke der Mitte,' but as the maximum diameter anteroposteriorly is generally found in the middle, this method should not deviate from that of the present writer's.

[2] Author's measurement on diagram.

[3] The lower figure was attained by resting the two feet of the coordinate calipers in the lateral depressions of the articular surface of the patella about coinciding with its horizontal bisector; the higher one by using the extreme margins of the articular surface, while in both cases the coordinate branch was lowered on the longitudinal crest (crista faciei articularis), the latter's height amounting to 9 and 10 mm. in the two cases. The proportions were then transmitted on paper and the angles measured. As regards the Spy-angle, Gorjanović-Kramberger says that it was measured 'bei der Basis,' yielding a figure then that is not directly comparable to the Mexican ones.

It is quite probable that cases of extreme emargination occur individually as a direct result of function, since man's lower limb is, with regard to the kinetics of his entire skeletal system, the most intensive functioning portion. Pathological causes, such as trauma and inflammatory processes, are fairly out of consideration here and are also dismissed as unjustifiable by Todd and

McCally ('21, p. 781), who, with regard to the causation of patellar defects, speak of various phases of an anomaly of patellar ossification. There is, however, another moment that may not be overlooked, namely, nature's apparent tendency toward economy in formative material. In the higher types this gives rise to the formation of muscle marks, such as tuberosities, ridges, and the like, which in the inferior types and the anthropoid apes are frequently seen only sparsely developed, a greater amount of osseous mass taking the place here of more differentiated conditions. Still another consideration would be that with regard to the bone whose less resistive qualities as a result of the influences

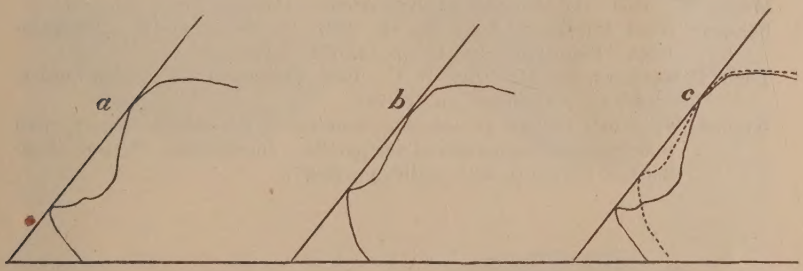

Fig. 4 Comparison of outlines showing emarginations of: *a*, the Mexican; *b*, the Krapina patella; *c*, superimposition of *a* and *b*. Natural size.

of more refined environmental conditions might, in conjunction with the above-named economy in formative material, be responsible for the specific relief known as muscle marks. Under that consideration a muscular insertion might eat itself deeply into certain bones like the patella to form the deep notch found there at times.

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PLATE 1

EXPLANATION OF FIGURES

Anomalous patellae, figures 5 and 6, *a* and *b*, represent the articular and anterior surfaces of two anomalous patellae from Chihuahua, Mexico, and Santa Catalina Id., California, the former marked by a deep insertional notch, the latter by an accessory bone ("patellula") filling up to the greater part a well marked notch.

a
5
b
a
6
b